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13. ABSTRACT *(Maximum 200 words)*

Theoretical models for the generation of gravity internal waves by flow over topography have been developed, in an effort to understand the role of orographically induced gravity waves in atmospheric turbulence production. For given background wind speed and distribution of buoyancy frequency, the location of the tropopause (the borderline between the troposphere and the stratosphere) is found to have a significant effect, consistent with observations of increased gravity-wave activity over New Mexico when the tropopause is 10–11km above ground. Based on a finite-amplitude hydrostatic model that accounts for three-dimensional effects, a theoretical explanation has been proposed for certain intense oblique gravity wave trains observed downstream of islands. Finally, the effects of periodic variations in the background buoyancy frequency have been studied. Under certain conditions, such fluctuations are found to cause trapping of mountain waves well below the tropopause while, in other instances, they result in unusually strong gravity– wave activity owing to a resonance phenomenon.

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The main objectives of this project was to understand the role of orographically induced internal gravity waves in atmospheric turbulence production. To this end, various theoretical models for the generation of gravity waves by flow over topography have been studied:

(i) We made a study of how the location of the tropopause (the borderline between the troposphere and the stratosphere) affects the gravity-wave field induced by flow over topography. When the tropopause is within a certain height range above the ground, depending on the wind speed and the background buoyancy frequency distribution, a 'resonance' phenomenon occurs, resulting in increased gravity-wave activity both above and below the tropopause. This tropopause-tuning effect is quite significant and is consistent with observations of increased gravity-wave activity in data taken over New Mexico when the tropopause is 10–11km above ground, as predicted by the theoretical model. Details can be found in Davis (1999), Lim (2001) and Akylas & Lim (2000).

(ii) We made an attempt to gain a quantitative understanding of how flow over three-dimensional topography differs from its two-dimensional counterpart—in prior work, apart from fully numerical simulations, very little theoretical progress has been made for three-dimensional nonlinear flow. We have developed a perturbation procedure to describe the gravity-wave field generated by nonlinear weakly three-dimensional topography (i.e., when variations in the spanwise direction are slower than in the

streamwise direction). It turns out that nonlinear interactions, precipitated by three-diimensional effects, give rise to oblique gravity waves far downstream that are quite distinct from the familiar lee waves. This mechanism is very robust and the theoretical findings are in good agreement with satellite photographs of gravity waves induced by wind over islands. Details can be found in Akylas & Davis (2001).

(iii) We explored the effects of periodic fluctuations in the background buoyancy-frequency distribution—such fluctuations are often present in field observations. Under certain conditions, such periodic fluctuations cause trapping of orographically induced gravity waves well below the tropopause while, in other instances, a resonance phenomenon occurs, resulting in unusually strong gravity-wave activity. Details can be found in Lim (2001).

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Publications

T. R. Akylas and K. S. Davis, 'Three-dimensional Aspects of Nonlinear Stratified Flow Over Topography Near the Hydrostatic Limit', *Journal of Fluid Mechanics* **428**, 81–105 (2001).

T. R. Akylas and K. S. Davis, 'Supercritical Wakes in Stratified Flows' 15th Inter-

national Workshop on Water Waves and Floating Bodies, Caesarea, Israel, February 2000. (Also presented at the 5th International Symposium on Stratified Flows, Vancouver, BC, July 2000).

K. S. Davis, 'Flow of Nonuniformly Stratified Fluid of Large Depth Over Topography', SM Thesis, MIT (1999).

K. Y. Lim, 'Trapped Disturbances and Effects of Tropopause Height in Stratified Flow Over Topography', SM Thesis, MIT (2001).

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